PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : H04N 7/08	A1	(11) International Publication Number: WO 94/17633
		(43) International Publication Date: 4 August 1994 (04.08.94)

(21) International Application Number: PCT/US94/00711

(22) International Filing Date: 18 January 1994 (18.01.94)

(30) Priority Data:
08/006,476   21 January 1993 (21.01.93)   US

(71) Applicant: SCIENTIFIC-ATLANTA, INC. [US/US]; One Technology Park, P.O. Box 105600, Atlanta, GA 30348 (US).

(72) Inventors: PRIMIANO, Guy, A.; 1930 Commonwealth Court, Cumming, GA 30131 (US). NAIR, Ajith, N.; 1941 Hunter's Ridge Drive, Lawrenceville, GA 30244 (US).

(74) Agents: ROCCI, Steven, J. et al.; Woodcock Washburn Kurtz Mackiewicz & Norris, One Liberty Place - 46th floor, Philadelphia, PA 19103 (US).

(81) Designated States: AU, BR, CA, JP, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
With amended claims and statement.

(54) Title: APPARATUS AND METHODS FOR PROVIDING CLOSE CAPTIONING IN A DIGITAL PROGRAM SERVICES DELIVERY SYSTEM
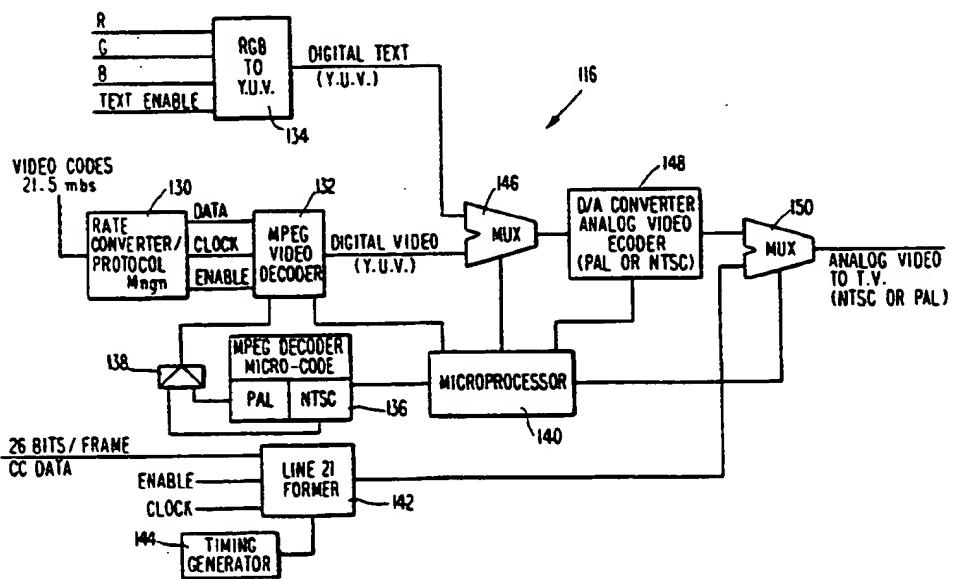
(57) Abstract

An apparatus for providing close captioning or text insertion in a digital program service delivery system comprising: a rate converter circuit (130) for receiving video codes and outputting video data, a video decoder circuit (132) for receiving the video data and outputting digital component video data, a digital to analog converter/analog encoder circuit (148) for converting the component video data into an analog video signal in a prescribed format; a line former circuit (142) for receiving close captioning digital data and forming a line of analog signal; a multiplexor (150) for inserting the line of analog signal into the analog video signal.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgystan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic	SD	Sudan
CG	Congo		of Korea	SE	Sweden
CH	Switzerland	KR	Republic of Korea	SI	Slovenia
CI	Côte d'Ivoire	KZ	Kazakhstan	SK	Slovakia
CM	Cameroon	LI	Liechtenstein	SN	Senegal
CN	China	LK	Sri Lanka	TD	Chad
CS	Czechoslovakia	LU	Luxembourg	TG	Togo
CZ	Czech Republic	LV	Latvia	TJ	Tajikistan
DE	Germany	MC	Monaco	TT	Trinidad and Tobago
DK	Denmark	MD	Republic of Moldova	UA	Ukraine
ES	Spain	MG	Madagascar	US	United States of America
FI	Finland	ML	Mali	UZ	Uzbekistan
FR	France	MN	Mongolia	VN	Viet Nam
GA	Gabon				

APPARATUS AND METHODS FOR PROVIDING CLOSE CAPTIONING IN A DIGITAL PROGRAM SERVICES DELIVERY SYSTEM

FIELD OF THE INVENTION

The present invention relates generally to
5   digital television systems, and relates particularly to
apparatus and methods for providing close captioning in a
digital program services delivery system.

BACKGROUND OF THE INVENTION

The background of the present invention is
10 described herein in the context of pay television systems,
such as cable television and direct broadcast satellite
(DBS) systems, that distribute a variety of program
services to subscribers, but the invention is by no means
limited thereto except as expressly set forth in the
15 accompanying claims.

In the pay television industry, programmers
produce programs for distribution to various remote
locations. A "program" may consist of video, audio and
other related services, such as closed-captioning and
20 teletext services. A single programmer may wish to supply
many programs and services. Typically, a programmer will
supply these services via satellite to individual
subscribers (i.e., DBS subscribers) and/or cable television
operators. In the case of cable television operators, the
25 services transmitted via satellite are received at the
operator's cable head-end installations. A cable operator
typically receives programs and other services from many
programmers and then selects the programs/services it

wishes to distribute to its subscribers. In addition, a cable operator may insert locally produced services at the cable-head end. The selected services and locally produced services are then transmitted to the individual subscribers

5   via a coaxial cable distribution network. In the case of DBS subscribers, each subscriber is capable of receiving a satellite down-link from the programmers directly.

In the past, pay television systems, including cable and DBS systems, have operated in the analog domain.

10   Recently, however, the pay television industry has begun to move toward all digital systems wherein, prior to transmission, all analog signals are converted to digital signals. Digital signal transmission offers the advantage that digital data can be processed at both the transmission

15   and reception ends to improve picture quality. Further, digital data compression techniques (e.g., DCT) have been developed that achieve high signal compression ratios. Digital compression allows a larger number of individual services to be transmitted within a fixed bandwidth.

20   Bandwidth limitations are imposed by both satellite transponders and coaxial cable distribution networks, and therefore digital compression is extremely advantageous.

Further background can be found in U.S. patent application Serial No. 968,846, October 30, 1992, titled

25   *System and Method for Transmitting a Plurality of Digital Services.* This application is hereby incorporated by reference as if fully set forth herein.

SUMMARY OF THE INVENTION

In accordance with the present invention, an

30   apparatus for providing close captioning or text insertion in a digital program services delivery system comprises a rate converter circuit receiving video codes and outputting video data; a video decoder circuit receiving the video data and outputting digital Y, U, V (component video) data;

35   a digital to analog converter/analog encoder circuit converting the Y, U, V data into an analog video signal in

a prescribed format; a line former circuit receiving close
captioning digital data or digital text data and forming a
line of analog text signal; and a multiplexor inserting the
line of analog text signal into the analog video signal.

5   In preferred embodiments of the present
invention, the line 21 former circuit comprises a data
stripper and storage circuit receiving close captioning
(CC) data, a CC enable signal, and a clock signal and
outputting data representing two CC characters per line 21;

10   a register receiving a frame sync signal and storing the CC
characters in response thereto, whereby two CC characters
are stored on a frame boundary; a start bit and dead time
insert circuit coupled to the register; a line 21 interval
former circuit receiving a line 21 enable signal and

15   outputting timing signals in response thereto; a digital
sinewave generator outputting a digital waveform signal; a
second multiplexor outputting CC data at a prescribed rate;
a digital to analog summing network receiving the CC data
and outputting an analog CC signal; and a low pass filter

20   filtering the analog CC signal and outputting a filtered
analog line 21 signal.

          In addition, embodiments of the invention may
advantageously comprise means for providing microcode to
the video decoder circuit. The microcode comprising

25   instructions for generating the digital Y, U, V data.

          A method in accordance with the present invention
comprise the steps of: decoding discrete cosine transform
(DCT) compressed video codes and generating video data
corresponding thereto; converting the video data into

30   digital Y, U, V data; converting the Y, U, V data into an
analog baseband video signal in a prescribed format;
processing close captioning digital data and forming a line
21 analog signal representative thereof; and inserting the
line 21 analog signal into the analog baseband video

35   signal.

          The system disclosed hereinbelow provides for the
transport of text and close-captioning data separately in

the multiplexor from video and audio data. Analog NTSC video provides close captioning data on line 21 of every other video field, i.e., once per frame. To transport that data separately in the multiplexor, it must first be

5 extracted from the analog NTSC signal at the encoder. Then, at the decoder, line 21 must be regenerated and reinserted in the reconstructed NTSC analog signal provided to a subscriber's television.

The present specification describes an apparatus

10 and method whereby line 21 reconstruction is performed digitally before converting the line 21 data to an analog signal. Consequently, the entire process can be carried out in one ASIC implementation rather than a mixture of discrete analog and digital circuits. The present

15 invention eases manufacturing and reduces decoder costs. Other features and advantages of the present invention are described below.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a partial block diagram of a system

20 for multiplexing a plurality of digital services for transmission to a plurality of remote locations, as described in U.S. patent application Serial No. 968,846.

Figure 2 is a graphical illustration of the multiplex data stream generated by each encoder of Figure

25 1.

Figure 3 shows in detail the general arrangement and contents of a frame of the multiplex data stream of Figure 2 for transmitting NTSC video services.

Figure 4 shows in detail the data and services

30 that can be carried in an exemplary first field of a frame of the multiplex data stream of Figure 2.

Figure 5 shows in detail the data and services that can be carried in an exemplary second field of a frame of the multiplex data stream of Figure 2.

Figure 6 is a block diagram illustrating, in a simplistic manner, an exemplary environment for the present invention.

Figure 7 is a block diagram of a decoder 116 in
5 accordance with the present invention.

Figure 8 depicts an exemplary line 21 waveform in accordance with the present invention.

Figure 9 is a block diagram of the line 21 former circuit 142 of Figure 7.

10 **DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS**

A portion of the disclosure in application Serial No. 968,846 is summarized hereinbelow to provide further information useful in explaining a specific application of the present invention. The present invention is
15 specifically described below with reference to Figures 6-9.

Figure 1 shows a partial block diagram of a system 10 for multiplexing a plurality of digital services for transmission to a plurality of remote locations (not shown). In the pay television context, the system 10
20 comprises a plurality of service encoders 12 each of which is operated by a "programmer." As illustrated, any number N of programmers may be present in the system 10. As mentioned in the background, programmers are entities that provide "programs" for distribution to various subscribers.
25 For example, as shown in Figure 1, programmer1 may provide programs1...N. Each program comprises a set of related services, such as video, audio and closed-captioning services. By way of example, Figure 1 shows that programmer1 is providing program1 which comprises a video
30 service 14 and two related audio services 16, 18. A given program can comprise a collection of related services, and a programmer may provide any number of programs.

Typically, the individual services of each program are produced in an analog format. According to the
35 system and method of the present invention, each encoder 12 has a plurality of analog-to-digital converters 20 for

converting services in analog form to digital services. In
addition, video and audio services may be compressed by
video and audio compression devices 22, however,
compression is not required. As those skilled in the art
5 know, there are many video and audio compression techniques
available. For example, the Motion Pictures Expert Group
(MPEG) has developed a video compression algorithm that is
widely used in the digital video services industry. Vector
quantization is another, more recent compression technique
10 for digital video. According to the present invention, any
compression algorithm may be employed by the video and
audio compression devices 22, and the devices 22 are by no
means limited to any one compression method. Furthermore,
as mentioned above, compression of audio and video services
15 is not required. Compression merely serves to increase the
amount of data that can be transmitted within a given
bandwidth.

        Each encoder further comprises a service
multiplexer 24. As described hereinafter in greater
20 detail, the service multiplexers 24 function in accordance
with the method of the present invention to multiplex the
individual digital services for transmission to remote
locations (not shown), such as a cable head-end
installation or DBS subscriber. The service multiplexer 24
25 in each encoder 12 generates a multiplex data stream which
is fed to a transmitter 28 for transmission to the remote
locations via a satellite 30. As illustrated in Figure 1,
each programmer (e.g., programmer1..programmerN) provides
its own multiplex data stream 26. As described hereinafter
30 in greater detail, the multiplex data streams may be
received at various remote locations, such as a cable head-
end, a DBS subscriber or a cable subscriber. Each remote
location employs a service demultiplexer which extracts
selected services from the multiplex stream in accordance
35 with the method of the present invention. Further details
of the service demultiplexer will be provided hereinafter.

Figure 2 is a graphical illustration of the
multiplex data stream 26 generated by each service
multiplexer 24 in each encoder 12. According to the
present invention, the multiplex data stream 26 comprises a
5   continuous sequence of "frames." Each frame consists of two
"fields" as shown. As described hereinafter in greater
detail, each field contains multiplexed service data and a
"transport layer" that contains certain "system data"
necessary for operating the system of the present
10   invention. Because certain types of system data are too
numerous to transmit in a single field, these types of data
are transmitted over a series of fields referred to herein
as a "cryptocycle." According to the present embodiment, a
cryptocycle nominally comprises eight (8) fields; however,
15   a cryptocycle can be defined by any number of fields.
Essentially, cryptocycles define fixed boundaries in the
multiplex data stream 26 within which a complete set of
system and encryption related data is transmitted. As
described hereinafter, the service demultiplexer at each
20   remote location needs all the system data in a given
cryptocycle in order to extract selected services from the
service data contained in the next cryptocycle.

As explained above in connection with Figure 1,
the video services carried in a multiplex data stream
25   typically originate as analog video signals (except for
HDTV signals), and as shown in Figure 1, the analog video
signals are "digitized" by analog-to-digital converters 20
and thus become "digital services." As described
hereinafter in greater detail, at subscriber locations,
30   selected digital video services are extracted from the
multiplex data stream for viewing on a display device, such
as a television, for example. Prior to viewing, however,
the digital video services must be converted back to their
analog form. As those skilled in the art know, there are
35   several analog video signal formats widely used in the
television industries. The NTSC format is widely used in
the United States, whereas the PAL format is used in most

of Europe. In order to simplify hardware design and
frequency generation throughout the system 10, the overall
frame structure and transmission rate of the multiplex data
stream 26 are related to, and depend upon, the particular

5   analog video format of the video services being carried in
the multiplex. The frame structure and digital
transmission rate of the multiplex differ depending upon
whether the video services carried in the multiplex are PAL
video signals or NTSC video signals. Providing digital

10   multiplex data rates and clocks that are related to key
analog video frequencies simplifies hardware design
throughout the system. In particular, the regeneration of
analog video (as well as audio) signals at subscriber
locations is greatly simplified.

15   Figure 3 shows the general arrangement and
contents of a frame of the multiplex data stream of Figure
2 when the video services carried in the multiplex are
based on the NTSC video signal format. The frame structure
and transmission rate of the multiplex data stream are

20   related to their analog NTSC counterparts. As described
below in greater detail, for example, the overall data rate
of the multiplex data stream is related to the analog
television line frequency F_h, which in the case of NTSC
video signals is 15.734 kHz (i.e., F_h=15.734 kHz). As

25   illustrated in Figure 3, a frame comprises a plurality of
lines each of which are 171 bytes long (i.e., 1368 bits).
In the present embodiment, wherein the video services
carried are NTSC format signals, the frame has 525 lines.
As those skilled in the art will recognize, the 525 lines

30   of the frame correspond to the number of lines in an analog
NTSC picture. Additionally, each frame consists of two
"fields," each of which contains 262 lines. A test line 40
is added to the second field to achieve the 525 line total.
As those skilled in the art will further recognize, this

35   two-field structure is analogous to the two-field format of
NTSC signals.

To achieve correspondence between the multiplex data rate and analog NTSC frequencies, each line of the frame is transmitted at a frequency equal to F_h, the horizontal line frequency. In the case of NTSC video, F_h is

5   15.734 kHz. Thus, when NTSC video services are carried in the multiplex, the multiplex data rate is:

$$\frac{171 \text{ bytes}}{\text{line}} \times \frac{8 \text{ bits}}{\text{byte}} \times F_h = 1368 \times F_h$$

$$= 1368 \times 15.734 \text{ kHz}$$

10                        $= 21.5$ Mbps

As expected, with 525 lines, the overall frame rate is 29.97 Hz which is equal to the analog frame rate of NTSC video signals. As those skilled in the art will recognize, the multiplex rate of 1368 F_h does not exactly match the

15 NTSC regeneration rate. The NTSC regeneration rate is actually 1365 F_h, and therefore, decoders at subscriber locations must perform a rate conversion in order to accurately regenerate the analog NTSC video signals. A single 21.5 Mbps multiplex data stream may be modulated and

20 transmitted within a 6Mhz cable channel, and two 21.5 Mbps multiplex data streams can be interleaved and transmitted over a single C-Band satellite transponder.

Referring still to Figure 3, each field of the frame begins with a VSYNC word 42, and each line begins

25 with an HSYNC byte 46 followed by an offset byte. As described hereinafter, a service demultiplexer in a decoder at each subscriber location uses the HSYNC and VSYNC patterns to establish frame and field synchronization after receiving a multiplex data stream. The VSYNC word 42 is

30 generated similarly for each field, but is bit-inverted every other field. The HSYNC byte 46 is the same for each line. The VSYNC word 42 in each field is followed by a "transport layer" 44. In general, the transport layer 44 in each field contains "system data" needed for operation

35 of the system of the present invention, and more importantly, specifies the contents and structure of the "system data" and service data that follow in the field.

As described hereinafter in greater detail, an important
part of the transport layer 44 is the "multiplex map" (not
shown) which follows directly after the VSYNC word 42 in
each field. The multiplex map specifies the number and
5 location of transport layer packets that follow in the
field and is dynamically adjustable on a per field basis to
achieve great flexibility.

As shown in Figure 3, the transport layer 44 of
each field is followed by a service data space 48 which
10 contains the audio and video service data carried in the
multiplex data stream. As explained hereinafter in greater
detail, the plurality of video services and audio services
carried in each field are variably partitioned within the
field so that the system can accommodate multiple service
15 data rates. The data rate for a service can vary from the
HDTV rate (approx. 17 Mbps) to the telecommunications
standard T1 data rate of 1.544 Mbps. The amount of data
assigned to video, audio and other services can be adjusted
among the services. Portions of the service data space not
20 used for audio services may be reassigned as video or other
service data. Audio services are not tied to video
services within the field, and therefore, the system can
provide "radio" services. Because of the dynamic
allocation of service data within a field, the individual
25 video services are not required to have the same data rate.
The possible combinations of services that a programmer can
provide in one multiplex data stream are limited only by
the maximum data rate of the multiplex data stream (i.e.,
21.5 Mbps) and the variable partitioning increment size.
30 With the flexible method of the present invention, any
future digital services with data rates as low as the
telecommunications standard T1 rate can be accommodated.
As further shown, the transport layer 44 and service data
portion 48 of each frame are error coded using a 20 byte
35 Reed-Solomon error correcting code. Those skilled in the
art will appreciate, however, that any block-oriented

error correcting scheme may be employed without deviating from the true spirit and scope of the present invention.

Figure 4 shows further details of the general arrangement and contents of the first field of an exemplary frame of a multiplex data stream in accordance with the present invention. As shown, the first line of the transport layer 44 (i.e., line 2 of the field) comprises a system data packet 60 (SDP) that includes a multiplex map 62. Subsequent lines of the transport layer may comprise service seed packets 64 (SSP), video multiplex control packets 66 (VMCP), virtual channel map packets 68 (VCM), teletext data packets 70 (TT), addressable data packets 72 (ADP), and optional system packets 74 (OSP). The multiplex map 62 is transmitted with each field and specifies the number and location of every other type of data packet in the transport layer 44 of that field. With the multiplex map 62, the number and location of each other type of transport layer packet may be dynamically altered on a per field basis to achieve a great degree of flexibility. For example, as described below in greater detail, the multiplex map 62 can be used in a "full-field" mode to allow an entire field of the multiplex data stream to be used for system data such as addressable data packets 74 (ADPs). It should be noted that not every type of transport layer packet need be transmitted in every field. For example, some packets, such as system seed packets 64 (SSPs), may be transmitted only in the first few fields of a cryptocycle. The content and arrangement of data within each packet will be described hereinafter in greater detail.

Still referring to Figure 4, a portion of each field is allocated to service data 48. According to the method of the present invention, audio services, utility data and closed-captioning services and video services are separated within the field. As shown, utility and closed-captioning data may be transmitted at the beginning of each line of the transport layer 44 as well. The audio portion

78 of each field is proportionally allocated among the
various audio services being transmitted. The size of the
audio portion 78 of each field is adjustable for
accommodating different numbers of audio services.

5   According to a preferred embodiment, the audio portion 78
of each field consists of a maximum of 21 bytes on each
line of the service data area 48.

The video portion 80 of the service data area 48
of each frame comprises a plurality of smaller video data

10   packets 82 (VDPs). In the present embodiment, the VDPs are
each 60 bits wide, although any size VDP may be used
without deviating from the spirit and scope of the
invention. Each of the 60 bits in an VDP may be allocated
to a particular video service being transmitted. For

15   example, if there are 5 video services being transmitted,
each service could be allocated 12 bits out of every VDP.
According to the method of the present invention, the 60
bits in each VDP are allocated among the various services
in proportion to the individual data rate of each service.

20   For example, a video service having a high rate may be
allocated more bits in each VDP than a video service having
a lower rate. Although the allocation of VDP bits in a
single frame remains fixed, the allocation may be adjusted
on a per frame basis. As explained hereafter in greater

25   detail, the video multiplex control packets (VMCPs) 66 in
the transport layer 44 specify the video service allocation
within the VDPs of a given field. In the preferred
embodiment, even though the VMCPs are transmitted in the
transport layer of every field, the allocation of services

30   within each VDP may be dynamically altered on a per frame
basis only. In this manner, the system and method of the
present invention supports statistical multiplexing. Those
skilled in the art will appreciate, however, that the
allocation of services within each VDP may be dynamically

35   altered on a per field basis, if desired.

Figure 5 shows details of a second field of an
exemplary frame of a multiplex data stream. As can be

seen, the second field is generally similar in structure
and arrangement to the first field; the main difference
being the addition of the test line 40. As mentioned
previously, the test line 40 is the last line of every
5   frame of the multiplex data stream and allows each field to
be exactly 261 lines (not including VSYNC). The test line
40 is not error coded with the Reed-Solomon code as are
lines 264-524 of the second field. The test line may be
used to carry system test data, if desired.

10   Referring to both Figures 4 and 5, the third and
fourth bytes on each line of each field carry utility and
closed-captioning data. Only the first 15 of 16 bits are
utilized for utility data; the 16th bit is used for closed-
captioning data. Additionally, five lines in each frame
15   (i.e., both fields) do not carry utility and closed-
captioning data. These include the two VSYNC lines 42, the
test line 40 and lines 2 and 264 of the first and second
fields respectively. The total bit capacity for utility
data for one frame is then:

20   (525-5)lines * (15 bits/line) = 7800 bits.
Those 7800 bits are partitioned into 8 separate "channels"
of utility data. Thus, there are 975 bits/channel in each
frame. These are error coded using a (3,2,13) convolution
FEC to yield an error-corrected capacity of:

25   975 * 2/3 = 650 bits/channel/frame.
The resultant maximum data rate for each channel of utility
data is then:

$$\frac{650 \text{ bits}}{\text{frame}} \times \frac{1 \text{ Frame}}{525 \text{ lines}} \times \frac{15,743 \text{ lines}}{s} = 19.48 \text{ KBps}$$

30

This rate is slightly higher than the industry standard
19.2 KBps rate, but with the excess capacity, worst-case
incoming data channels can be handled by running at the
slightly higher rate. A 19.48 kHz clock is easily derived
35   from F_h since 19.48 kHz is equal to $2730/2205 \, F_h$. This
illustrates one advantage of relating the overall multiplex
data rate to the horizontal line frequency. Alternatively,

the utility data in each frame can be partitioned into 16
separate channels, where each channel runs at 9600 Kbps.

Closed-captioning data is transmitted in the last
bit of the fourth byte of each line (i.e., bit 16 of the
5   utility & closed-captioning data space). As with the
utility data, closed-captioning data (i.e., 1 bit per line)
is sent on the same 520 lines of each frame. As those
skilled in the art know, video services often have
associated closed-captioning data. In the analog NTSC
10 format, two bytes (i.e., two characters) of closed-
captioning data are sent on line 21 of each analog video
frame. The 520 closed-captioning bits are partitioned into
20 separate "channels" of 26 bits each. Each "channel"
corresponds to a different video service in the multiplex
15 data stream. In each frame, therefore, up to 20 video
services may carry associated closed captioning data. The
first 26 bits in the frame correspond to video number 1,
the second 26 bits correspond to video number 2, and so on.
In the present embodiment, only the first sixteen bits of
20 each 26 bit partition are used. Thus, as with line 21 in
the analog NTSC format, two characters are transmitted per
frame per video service.

Figure 6 is a block diagram schematically
illustrating one preferred environment for the present
25 invention. This figure has been simplified to place the
present invention in context. Analog NTSC video (or PAL)
is received from the programmer, and the Close-captioning
(CC) data is separated from the analog signal by a data
separation circuit 110, which is commercially available.
30 All the analog data is converted to digital data and
eventually finds its way into the 21.5 Mbps Multiplex.

After being encoded by an MPEG encoder 112 and
multiplexed by a multiplexer 114, the multiplexed data is
fed to a transport ASIC 118 in a decoder 116 (i.e., after
35 passing through the uplink and downlink channels), which
decoder demultiplexes the data and provides the CC, TEXT
and Video data separately to a video board 120 that

digitally recreates the original line 21 and converts it to
analog form. The video board also decodes the MPEG encoded
video, converts it to analog and inserts line 21 in the
appropriate field, thereby reproducing the original NTSC
5   video signal. The system is also capable of reconstructing
PAL video signals.

        Figure 7 shows details of the video board of
Figure 6. As shown, teletext data in digital RGB form is
received and fed to an RGB-to-YUV converter 134 and then
10   passed to a multiplexor 146. MPEG encoded video is
received at the 21.5 Mbps rate and fed to a rate
converter/protocol manager 130. From there the encoded
video is decoded using an MPEG Video Decoder Chip 132,
which is available from C-Cube Microsystems (part no.
15   CL950). The MPEG Chip is capable of decoding both NTSC and
PAL video, depending on the microcode it receives from a
memory 136 via a switch 138. The decoded video is then
sent to the other input of the multiplexor 146. Thus,
either teletext or decoded NTSC (or PAL) video will be
20   provided to a D/A converter/Analog video encoder 148, the
latter device outputting baseband video signals. The D/A
converter is capable of producing either NTSC or PAL analog
signals from digital inputs. The microprocessor tells both
the MPEG decoder and the analog video encoder which signal
25   to produce. The multiplexer is described in detail in the
above-referenced U.S. patent application Serial No.
968,846.

        Close-captioning data is fed to the decoder 116
at a rate of 26 bits per frame. As shown in Figure 7, the
30   26 bits of CC data are passed to a line 21 former circuit
142, which regenerates line 21 in analog form. The line 21
former circuit and an associated timing generator circuit
144 are described below with reference to Figure 8. Once
formed, line 21 is inserted into the proper NTSC analog
35   video field by a second multiplexor 150. The circuit is
controlled by a microprocessor 140.

Figure 8 illustrates the line 21 waveform. The
signal begins with a start bit. The start bit is followed
by a sinewave (RUN IN) which is used to alert a CC decoder
and establish synchronization. The sinewave is followed by
5   two characters of close-captioning text (CHAR 1, CHAR 2).
A stop bit (STOP) follows. When a subscriber buys a close-
captioning decoder, that decoder simply pulls line 21 out
of every NTSC frame, buffers the CC text characters until
full sentences have been received, and then displays them
10   on the screen for the user to read. This process is
described below.

Figure 9 depicts details of the line 21 former
circuit 142 of Figure 7. The 26 bits of CC data provided
in each frame are received by a data stripper and storage
15   unit 160 that buffers the received data and separates every
two characters (i.e., bytes) of CC data. The two
characters to be inserted in a given line 21 are then
stored in a 16-bit register 162. The register is clocked
with a frame sync signal so that the characters are
20   provided on a frame boundary (recall that line 21 is
provided every other field, i.e., once per frame). The two
characters are then sent to a circuit 164 that inserts the
start bit and required dead time into the signal. The CC
information is still digital at this point. This is then
25   fed to a multiplexor 170. A digital sinewave generator 168
creates a digital sinewave which is supplied to the other
input if the multiplexor 170.

When line 21 is required to be formed, the line
21 enable line goes high for the entire line 21 interval.
30   This enables the Line 21 interval former circuit 166, which
controls the timing of various circuit components.
Specifically, the line 21 interval former controls the
multiplexor 170, the sinewave generator 168, and the start
bit and dead-time insert circuit 164 so that a complete
35   digital representation is converted to analog in a D/A
summing network 172. The analog signal is then low-pass
filtered by a filter 174 to remove sharp edges. The result

is an analog reconstruction of the original line 21 that
was separated from the NTSC video at the encoder 112. The
reconstructed line 21 is then inserted into the appropriate
analog NTSC field.

5   One advantage of the circuit of Figure 9 is that
line 21 is first completely reconstructed digitally.
Specifically, the sinewave is reconstructed digitally, and
then the entire digital representation is D/A converted.
Another option would be to generate the sinewave in analog.

10   However, by constructing the sinewave digitally, the entire
line 21 former circuit can be implemented in a single ASIC.
Thus, a mix of discrete analog and digital circuitry is not
required.

It will be appreciated by those skilled in the

15   art that changes could be made to the embodiments described
above without departing from the broad inventive concepts
thereof. It is understood, therefore, that this invention
is not limited to the particular embodiments disclosed, but
is intended to cover all modifications which are within the

20   scope and spirit of the invention as defined by the
appended claims.

We claim:

1. An apparatus for providing close captioning in a digital program services delivery system, comprising:

    (a) a rate converter circuit receiving video codes and outputting video data;

5   (b) a video decoder circuit, coupled to said rate converter circuit, receiving said video data and outputting digital component video data;

    (c) a digital to analog converter/analog encoder circuit, operatively coupled to said video decoder circuit,

10 converting said component video data into an analog video signal in a prescribed format;

    (d) a line former circuit receiving digital text data and forming a line of analog text signal; and

    (e) a multiplexor, coupled to said digital to

15 analog converter/analog encoder circuit and said line former circuit, inserting said line of analog text signal into said analog video signal.

2. The apparatus recited in claim 1, wherein said line former circuit comprises:

20 a data stripper and storage circuit receiving text data, an enable signal, and a clock signal and outputting data representing two text characters per line;

    a register, coupled to said data stripper

25 and storage circuit, receiving a frame sync signal and storing said text characters in response thereto, whereby two text characters are stored on a frame boundary;

    a start bit and dead time insert circuit coupled to said register;

30 a line interval former circuit receiving a line enable signal and outputting timing signals in response thereto;

    a digital sinewave generator, coupled to said line interval former circuit, outputting a digital

35 waveform signal;

a second multiplexor, coupled to said start
bit and dead time insert circuit, digital sinewave
generator, and line interval former circuit, outputting
text data at a prescribed rate;

5   a digital to analog summing network, coupled
to said second multiplexor, receiving said text data and
outputting an analog text signal; and

a low pass filter, coupled to said digital
to analog summing network, filtering said analog text

10 signal and outputting a filtered analog line signal.

3.   The apparatus recited in claim 1, further
comprising means for providing microcode to said video
decoder circuit, said microcode comprising instructions for
generating said digital component video data.

15   4.   The apparatus recited in claim 2, further
comprising means for providing microcode to said video
decoder circuit, said microcode comprising instructions for
generating said digital component video data.

5.   Means for providing close captioning in a

20 digital program services delivery system, comprising:

(a)   rate converter means for receiving discrete
cosine transform (DCT) compressed video codes and
outputting video data;

(b)   motion pictures expert group (MPEG) video

25 decoder means coupled to said rate converter means for
receiving said video data and outputting digital component
video data;

(c)   digital to analog converter/analog encoder
means operatively coupled to said MPEG video decoder means

30 for converting said component video data into an analog
baseband video signal in a prescribed format;

(d)   line former means for receiving digital text
data and forming a line of analog text signal; and

(e)   multiplexor means, coupled to said digital
to analog converter/analog encoder means and said line
former means, for inserting said line of analog text signal
into said analog baseband video signal.

5   6.   The apparatus recited in claim 5, wherein
said line former means comprises:
                data stripper and storage means for
receiving close captioning (CC) data, an enable signal, and
a clock signal and outputting data representing two text
10 characters per line ;
                register means coupled to said data stripper
and storage means for receiving a frame sync signal and
storing said text characters in response thereto, whereby
two text characters are stored on a frame boundary;
15   start bit and dead time insert means coupled
to said register means;
                line interval former means for receiving a
line enable signal and outputting timing signals in
response thereto;
20   digital sinewave generator means coupled to
said line interval former means for outputting a digital
waveform signal;
                second multiplexor means, coupled to said
start bit and dead time insert means, digital sinewave
25 generator means, and line interval former means, for
outputting text data at a prescribed rate;
                digital to analog summing means coupled to
said second multiplexor means for receiving said text data
therefrom and outputting an analog text signal; and
30   low pass filter means coupled to said
digital to analog summing means for filtering said analog
text signal and outputting a filtered analog line signal.

        7.   The apparatus recited in claim 5, further
comprising means for providing microcode to said MPEG video

decoder means, said microcode comprising instructions for
generating said digital component video data.

8. The apparatus recited in claim 6, further
comprising means for providing microcode to said MPEG video
5   decoder means, said microcode comprising instructions for
generating said digital component video data.

9. A method for providing text insertion in a
digital program services delivery system, comprising the
steps of:
10   (a)   decoding discrete cosine transform (DCT)
compressed video codes and generating video data
corresponding thereto;
            (b)   converting said video data into digital
component video data;
15   (c)   converting said component video data into an
analog baseband video signal in a prescribed format;
            (d)   processing digital text data and forming a
line of analog text signal representative thereof; and
            (e)   inserting said line of analog text signal
20   into said analog baseband video signal.

AMENDED CLAIMS
[received by the International Bureau on 14 June 1994 (14.06.94);
original claims 2 and 6 amended; remaining claims unchanged (2 pages)]

1. An apparatus for providing close captioning in a digital program services delivery system, comprising:

(a) a rate converter circuit receiving video codes and outputting video data;

- 5 (b) a video decoder circuit, coupled to said rate converter circuit, receiving said video data and outputting digital component video data;

(c) a digital to analog converter/analog encoder circuit, operatively coupled to said video decoder circuit,

10 converting said component video data into an analog video signal in a prescribed format;

(d) a line former circuit receiving digital text data and forming a line of analog text signal; and

(e) a multiplexor, coupled to said digital to

15 analog converter/analog encoder circuit and said line former circuit, inserting said line of analog text signal into said analog video signal.

2. The apparatus recited in claim 1, wherein said line former circuit comprises:

20   a data stripper and storage circuit receiving digital text data, an enable signal, and a clock signal and outputting data representing two text characters per line;

a register, coupled to said data stripper

25 and storage circuit, receiving a frame sync signal and storing said text characters in response thereto, whereby two text characters are stored on a frame boundary;

a start bit and dead time insert circuit coupled to said register;

30   a line interval former circuit receiving a line enable signal and outputting timing signals in response thereto;

a digital sinewave generator, coupled to said line interval former circuit, outputting a digital

35 waveform signal;

AMENDED SHEET (ARTICLE 19)

(e) multiplexor means, coupled to said digital to analog converter/analog encoder means and said line former means, for inserting said line of analog text signal into said analog baseband video signal.

5   6. The apparatus recited in claim 5, wherein said line former means comprises:

data stripper and storage means for receiving digital text data, an enable signal, and a clock signal and outputting data representing two text characters

10 per line ;

register means coupled to said data stripper and storage means for receiving a frame sync signal and storing said text characters in response thereto, whereby two text characters are stored on a frame boundary;

15   start bit and dead time insert means coupled to said register means;

line interval former means for receiving a line enable signal and outputting timing signals in response thereto;

20   digital sinewave generator means coupled to said line interval former means for outputting a digital waveform signal;

second multiplexor means, coupled to said start bit and dead time insert means, digital sinewave

25 generator means, and line interval former means, for outputting text data at a prescribed rate;

digital to analog summing means coupled to said second multiplexor means for receiving said text data therefrom and outputting an analog text signal; and

30   low pass filter means coupled to said digital to analog summing means for filtering said analog text signal and outputting a filtered analog line signal.

7. The apparatus recited in claim 5, further comprising means for providing microcode to said MPEG video

AMENDED SHEET (ARTICLE 19)

STATEMENT UNDER ARTICLE 19

Claims 2 and 6 have been amended to conform with the amendment of claims 2 and 6 in the corresponding U.S. application. S.N. 08/006,476.

Fig.1
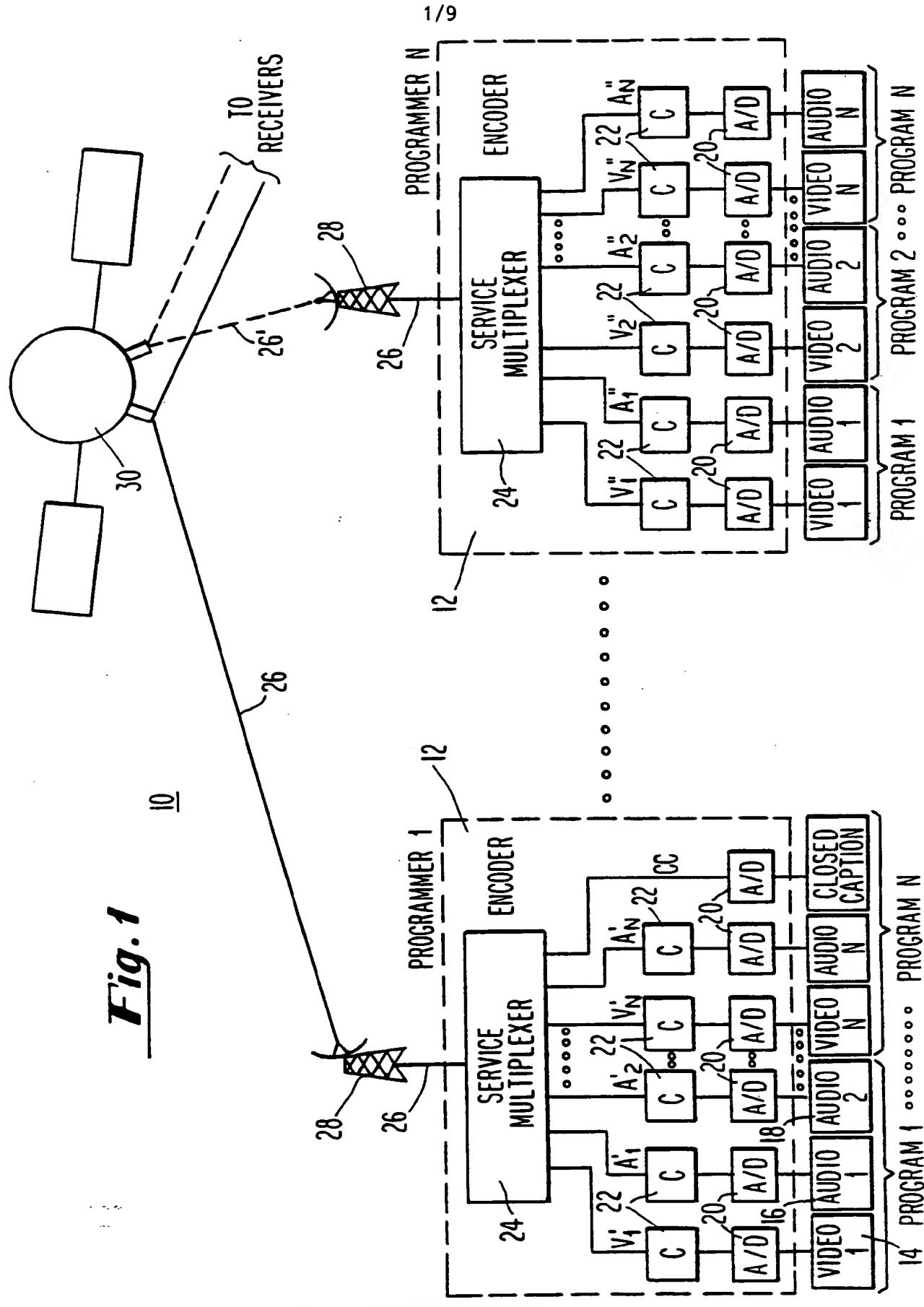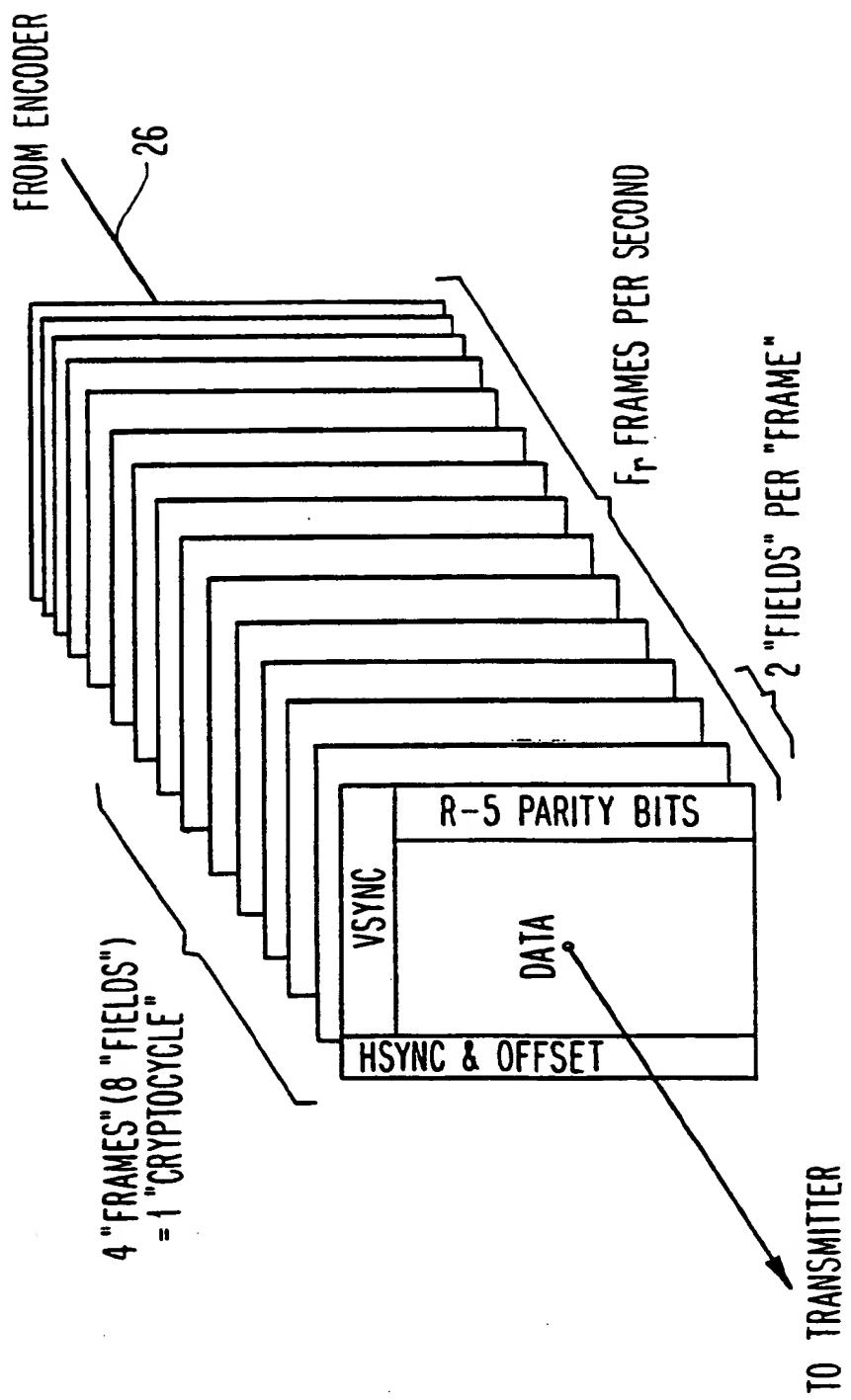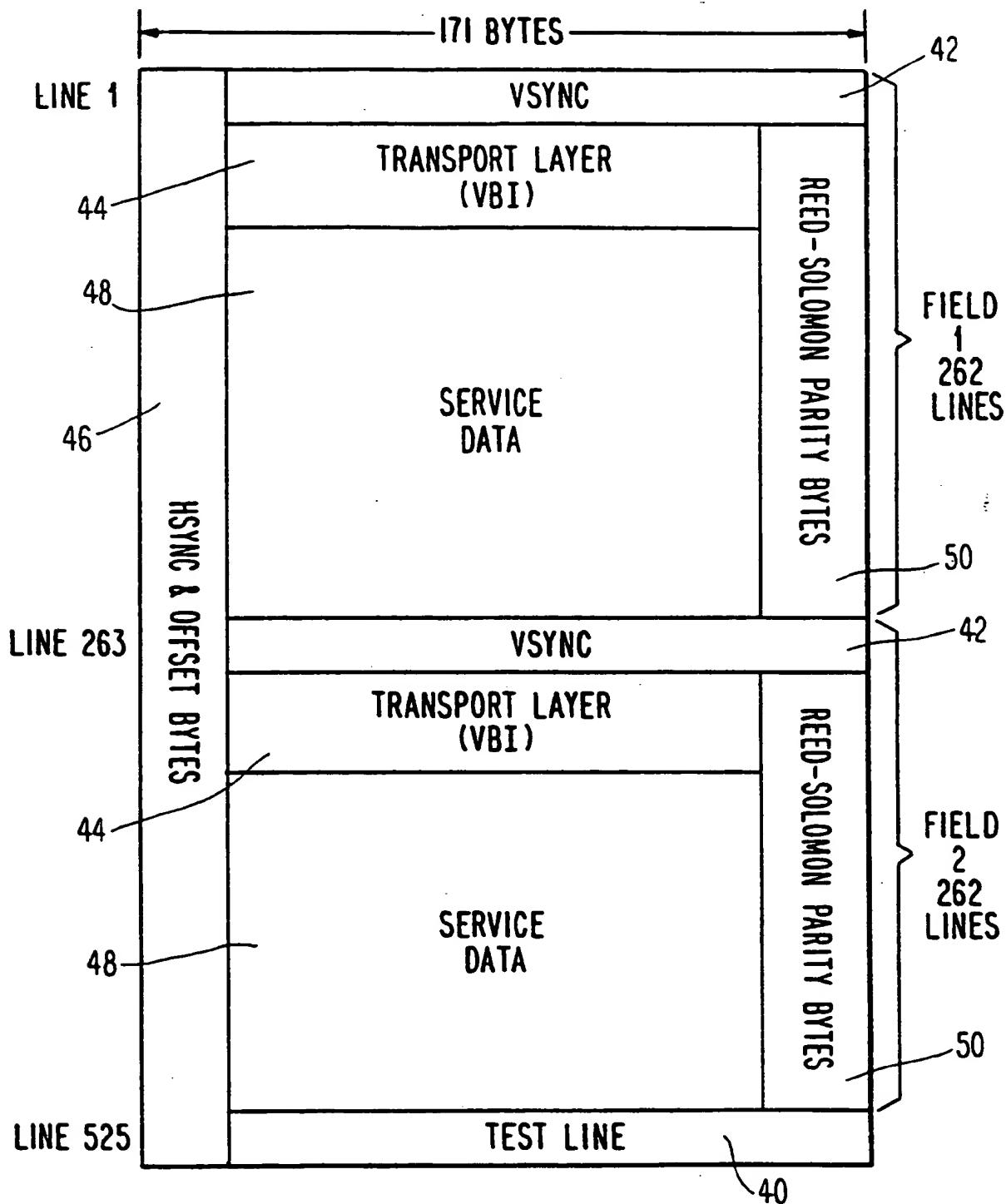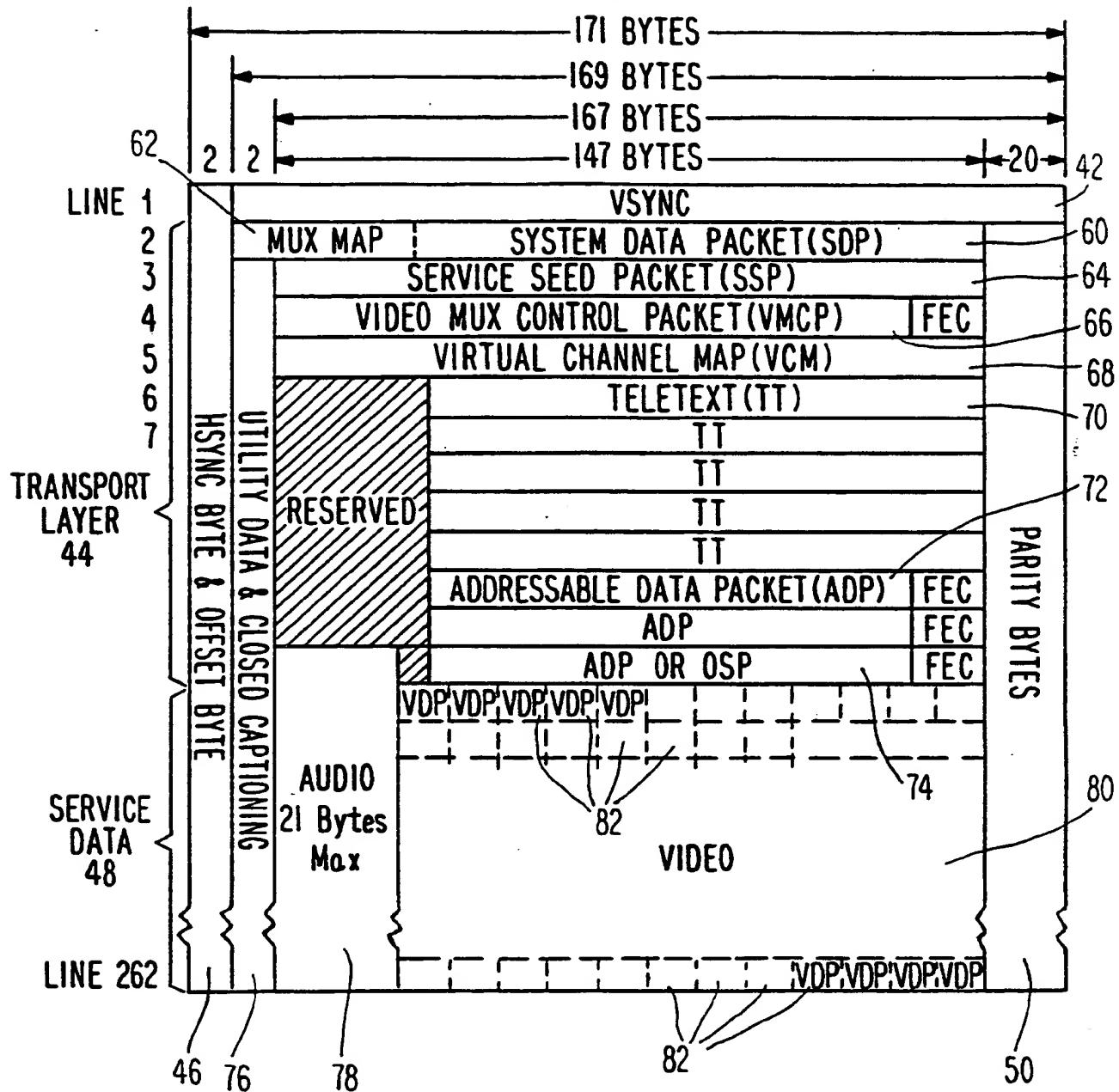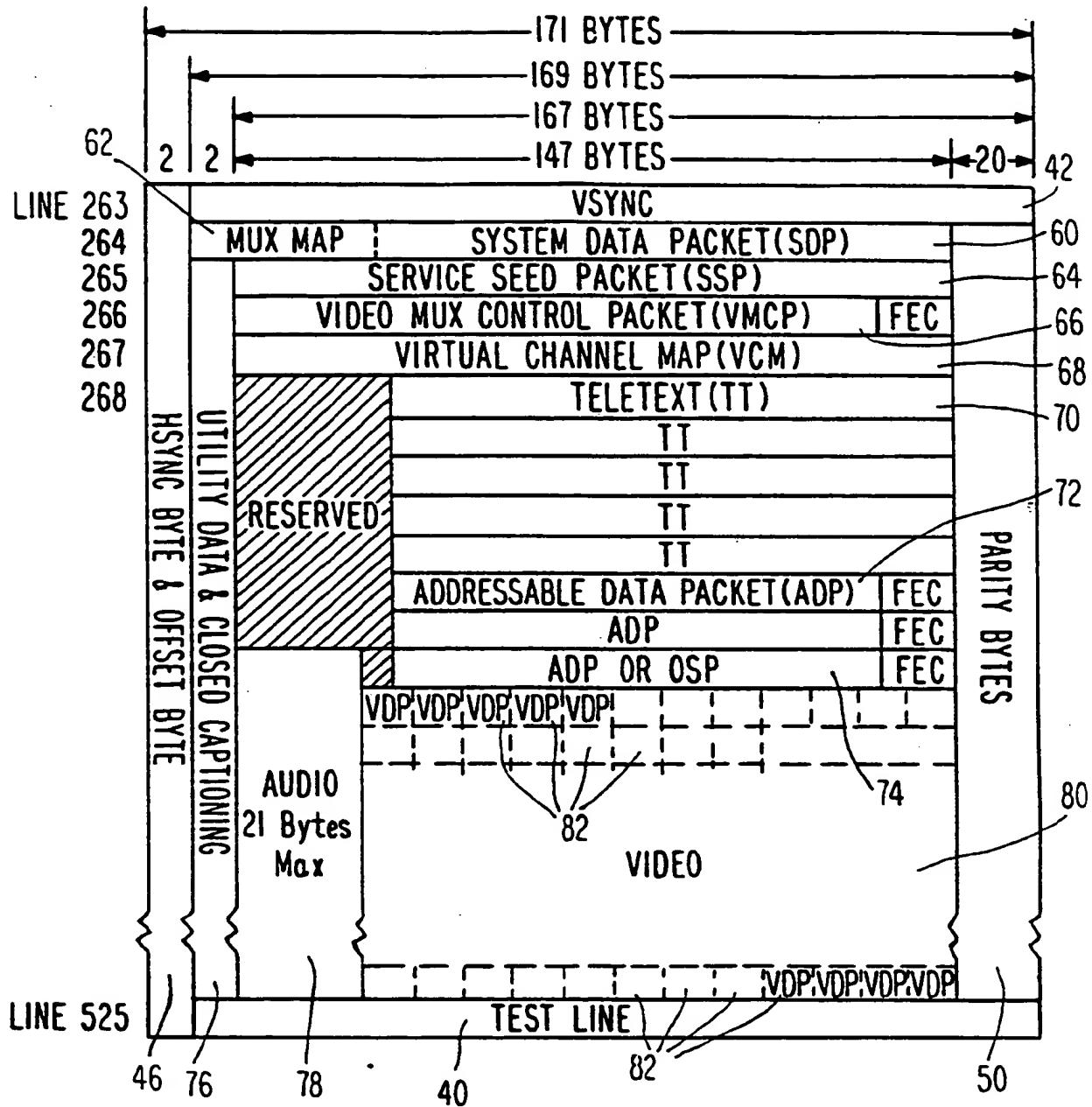
FROM ENCODER

26

F_r FRAMES PER SECOND

2 "FIELDS" PER "FRAME"

4 "FRAMES" (8 "FIELDS")
= 1 "CRYPTOCYCLE"

R-5 PARITY BITS

VSYNC

DATA

HSYNC & OFFSET

TO TRANSMITTER

Fig. 2

Fig. 3

Fig. 4

BNSDOCID: <WO___9417633A1_I_>

Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig. 9
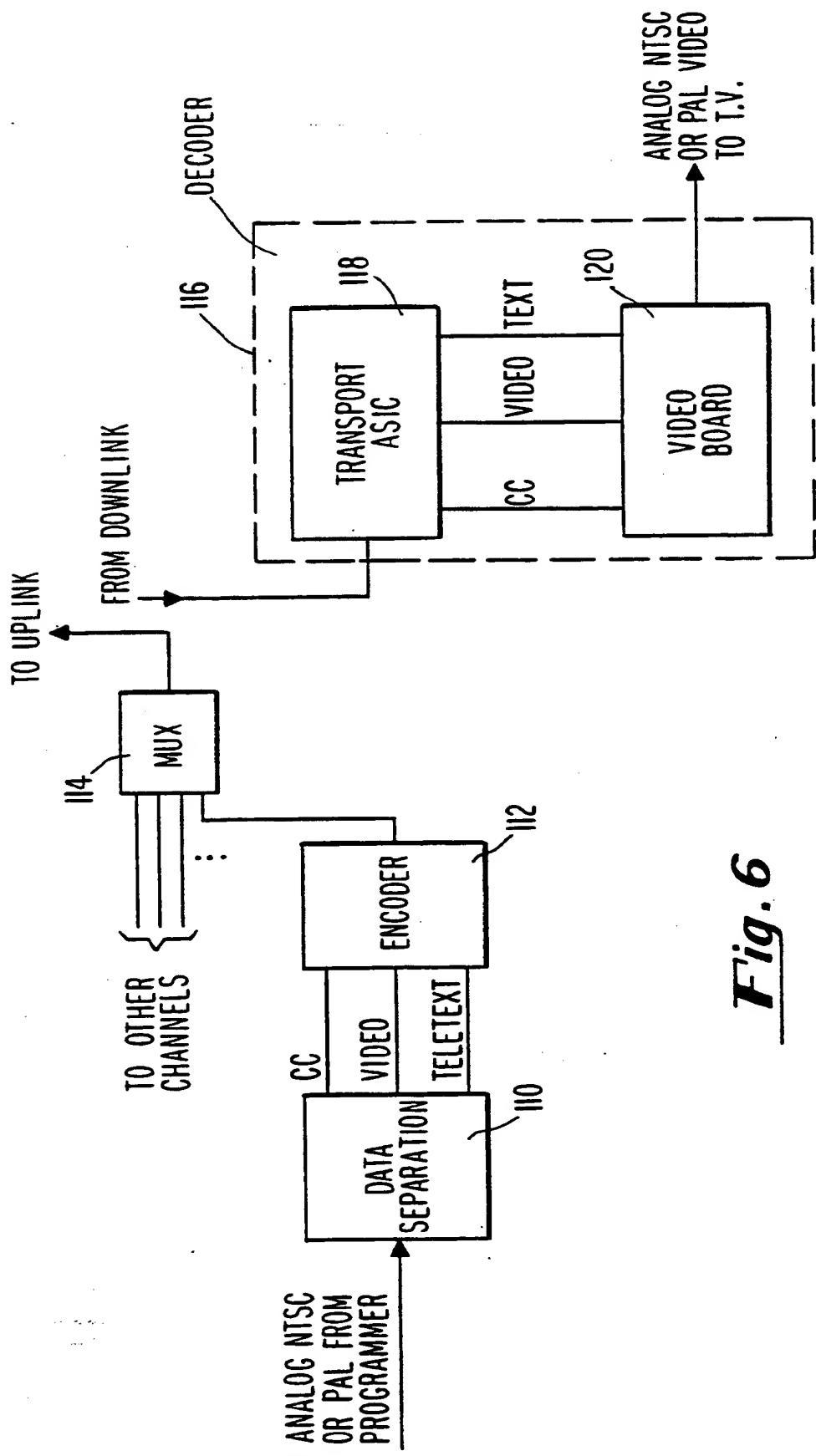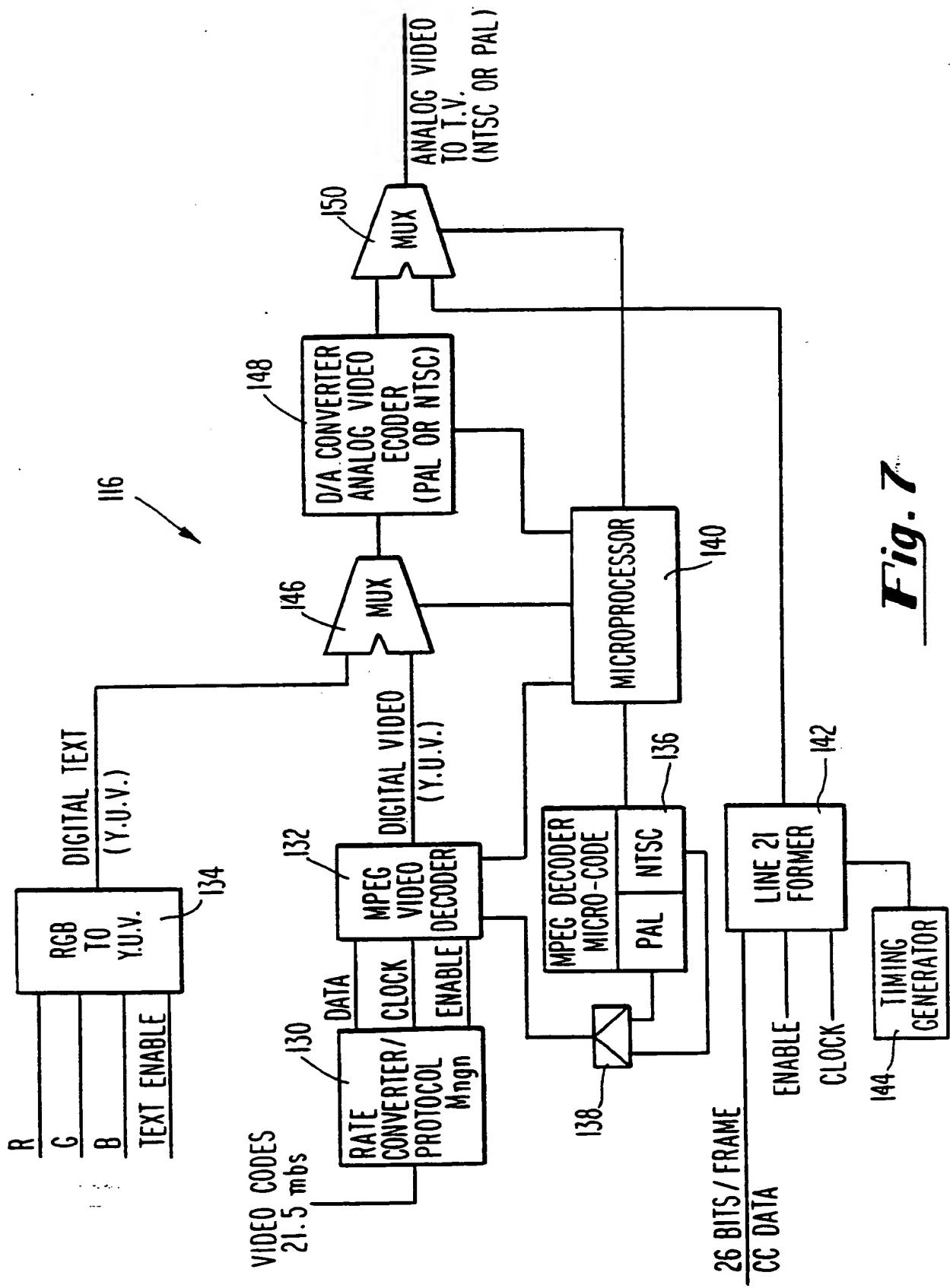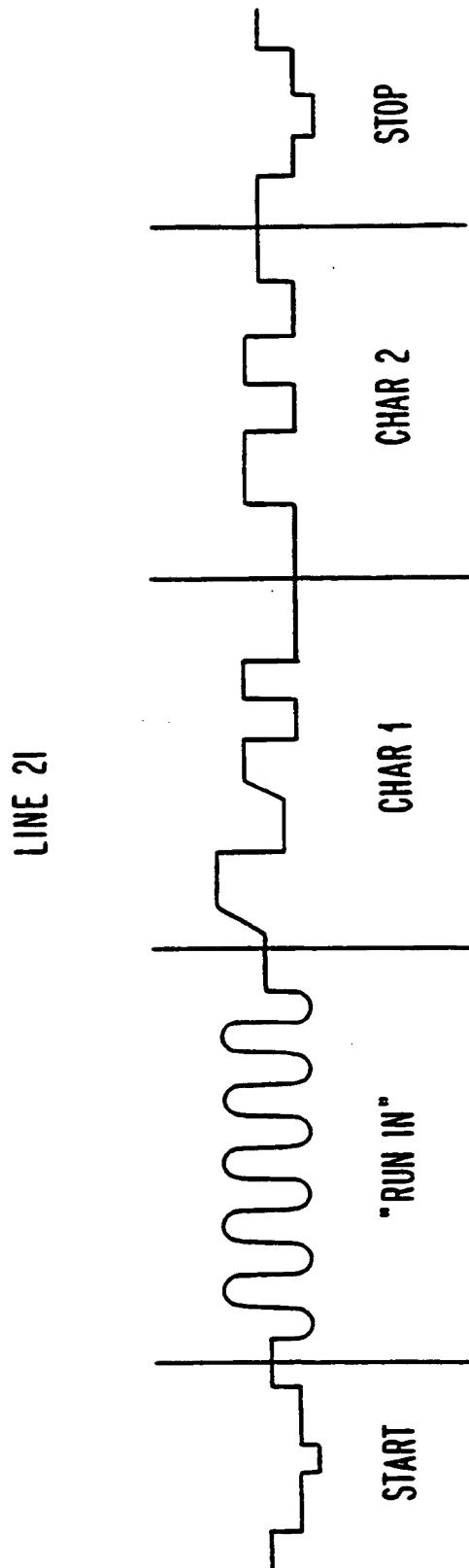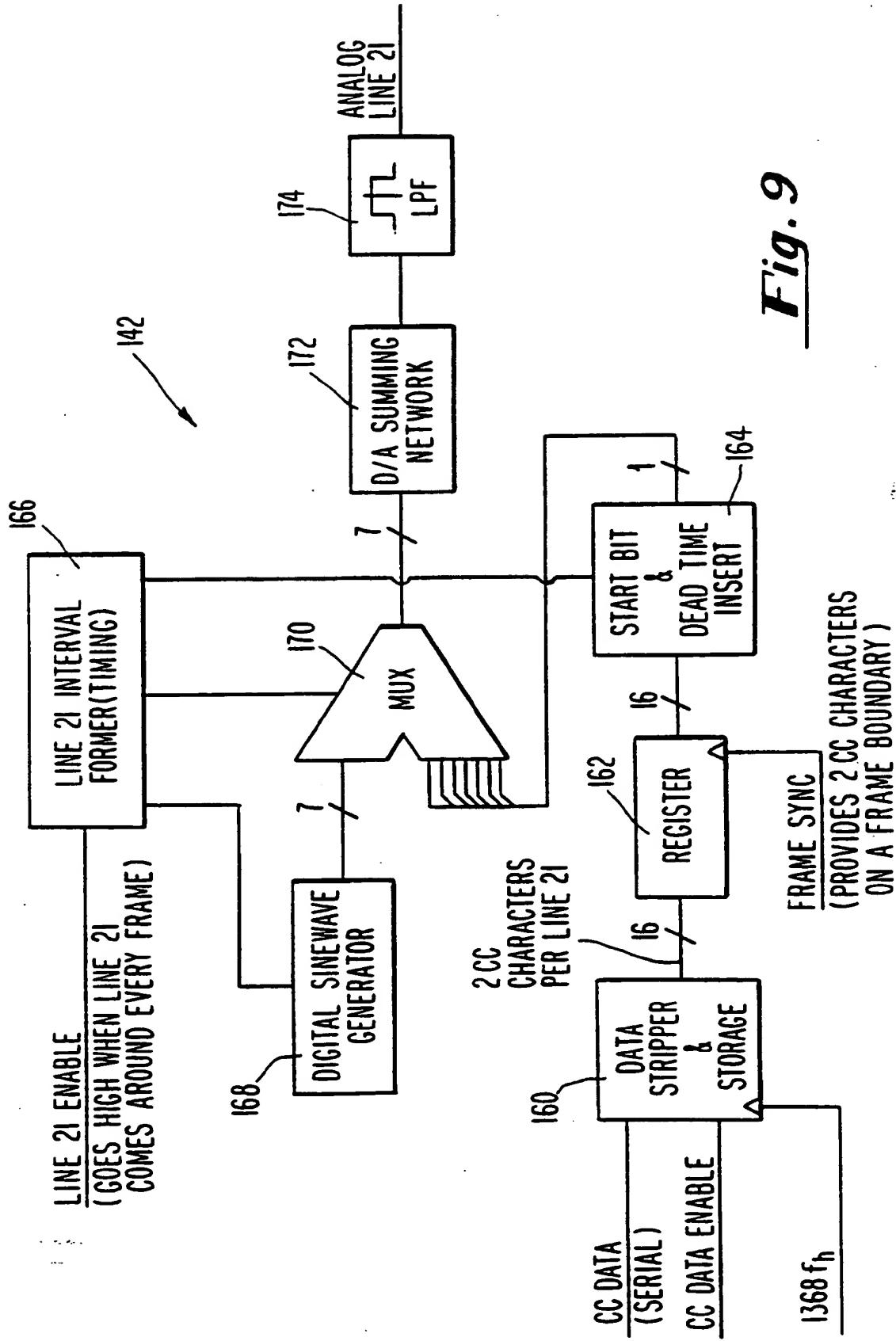
INTERNATIONAL SEARCH REPORT

A.	CLASSIFICATION OF SUBJECT MATTER

IPC(5) :H04N 7/08
US CL :348/461

According to International Patent Classification (IPC) or to both national classification and IPC

B.	FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 348/461, 465, 468, 476, 563
H04N 7/08, 7/087

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C.	DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A, 4,361,848 (POIGNET et al.) 30 November 1982, Figs 1-4.	1-9
A	US,A, 5,181,113 (CHANG) 19 January 1993, Figs 1-10.	1-9
A	GB, A, 2 225 519 (YAMADA et al.) 30 May 1990, Figs 1-8.	1-9

☐ Further documents are listed in the continuation of Box C.   ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be part of particular relevance		
"E"	earlier document published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed	"&"	document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 MAY 1994	03 JUN 1994

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	NATHAN J. FLYNN
Facsimile No. N/A	Telephone No. (703) 308-6601

Form PCT/ISA/210 (second sheet)(July 1992)*